ONTARIO POWER GENERATION

Report

Internal Use Only	
Document Number: NK38-REP-10140-10030	Usage Classification: N/A
Sheet Number: N/A	Revision: R000

Title:

2019 DARLINGTON NUCLEAR GROUNDWATER MONITORING PROGRAM RESULTS

2019 Darlington Nuclear Groundwater Monitoring Program Results

NK38-REP-10140-10030-R000
2020-07-20

Order Number: N/A
Other Reference Number:

Internal Use Only

Prepared By: A. Yung
Environmental Advisor
Environment Programs - Nuclear

Reviewed By: T. Ghosh
Environmental Advisor
Environment Programs - Nuclear

Reviewed By: A. Esmaeily
Section Manager
Environment Programs - Nuclear

Reviewed By: L. Yiu
Section Manager
Environment Operations Support – Darlington Site and Darlington Refurbishment

Reviewed By: K. Bramma
Senior Manager
Environment Operations Support - Nuclear

Approved By: R. McCalla
Director
Environment Nuclear

Table of Contents

List of Figures (within Report)

List of Graphs (within Report)

List of Appendices

Executive Summary

Darlington Nuclear Generating Station (DNGS) has a mature and robust groundwater monitoring program in place to address the following primary objectives:

1. Confirm predominant on-site groundwater flow characteristics at the DNGS site;
2. Monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases to groundwater; and
3. Ensure that there are no adverse off-site impacts from DNGS groundwater.

In 2019, groundwater samples were collected as per the Sampling and Analysis Plan (SAP) developed for the site, from a total of 81 sampling locations.

The findings with respect to the above objectives are:

- The predominant shallow groundwater flow patterns remain unchanged in 2019 from the original site groundwater flow interpretations. Outside the protected area, groundwater generally flows from the north towards the Lake. Inside the protected area (in the vicinity of the powerhouse), the groundwater flows northwest towards the Forebay. Further south of the powerhouse, there is a component of groundwater flow that is directed towards Lake Ontario.
- The groundwater data collected from key areas at DNGS indicate that tritium concentrations have remained constant or decreased over time, which points to stable or improved environmental performance. Groundwater monitoring will continue in these areas.
- In 2019, there were no indications of adverse off-site impacts from DNGS groundwater. Tritium concentrations at perimeter groundwater monitoring locations remained very low. Municipal drinking water samples collected from downstream Water Supply Plants (WSP), as part of the annual Ontario Power Generation (OPG) DNGS Environmental Monitoring Program (EMP), were well below the Ontario Drinking Water Quality Standard (ODWQS) for tritium of 7,000 Bq/L.

1.0 INTRODUCTION

Ontario Power Generation (OPG), Darlington Nuclear Generating Station (DNGS), has a mature and robust annual groundwater monitoring program in place. The program examines the chemical, radiological, and physical characteristics of the groundwater beneath the site.

The specific objectives of this program are:

1. **Objective 1**: Confirm predominant on-site groundwater flow characteristics at the DNGS site;

2. **Objective 2:** Monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases to groundwater; and

3. **Objective 3:** Ensure that there are no adverse off-site impacts from DNGS groundwater.

This report presents groundwater data collected at DNGS for the period from January 1st to December 31st, 2019, and the associated interpretation of this data.

2.0 PROGRAM DESIGN

The design of the DNGS groundwater monitoring program is risk-based in nature. The 2019 groundwater Sampling and Analysis Plan (SAP) was developed to meet the three objectives listed above.

The 2019 SAP specified the sampling locations, the frequency of sampling, (e.g. quarterly, annually), and the parameters for analysis.

The methodology used to collect data and subsequently draw conclusions for each objective is discussed in further detail below.

2.1 Objective 1 Methodology

Groundwater flow interpretations for DNGS were first established in 2010. On an annual basis, a set of water levels was collected from specific groundwater monitoring wells in order to verify that the original interpretations have not changed, and that OPG continues to have a sound understanding of groundwater flow patterns at the site. In the second quarter of 2019 (2019 Q2), water level readings were collected from selected monitoring locations. The data was subsequently used to calculate the groundwater elevation at each monitoring well and generate contour illustrations to visually verify the flow patterns.

2.2 Objective 2 Methodology

In 2019, groundwater samples were collected from a total of 81 monitoring wells, as shown on Figures 1 and 2. The monitoring wells are distinguished by location;

protected area (near the reactor buildings), controlled area (farther away from the reactor buildings but within the fence), and the site perimeter.

Groundwater samples were collected by qualified technicians. Prior to sample collection, each monitoring well was purged to remove standing water, ensuring that representative groundwater flowed into the well. Collected samples were predominantly analyzed for tritium. Selected samples were analyzed for petroleum hydrocarbons (PHCs) and benzene / toluene / ethylbenzene / xylenes (BTEX). Groundwater samples were analyzed by Bureau Veritas Canada Inc. (formerly Maxxam Analytics).

The groundwater data generated from the sampling program was subsequently analyzed to either support previous conclusions, identify adverse trends, or demonstrate no significant change.

2.3 Objective 3 Methodology

The sampling of monitoring wells at the site boundary was performed in order to confirm that there are no adverse off-site impacts from DNGS groundwater. These locations can also be seen on Figure 1. The methodology for groundwater collection and analysis, as well as for data evaluation, was the same for the site perimeter wells as what is described above for Objective 2.

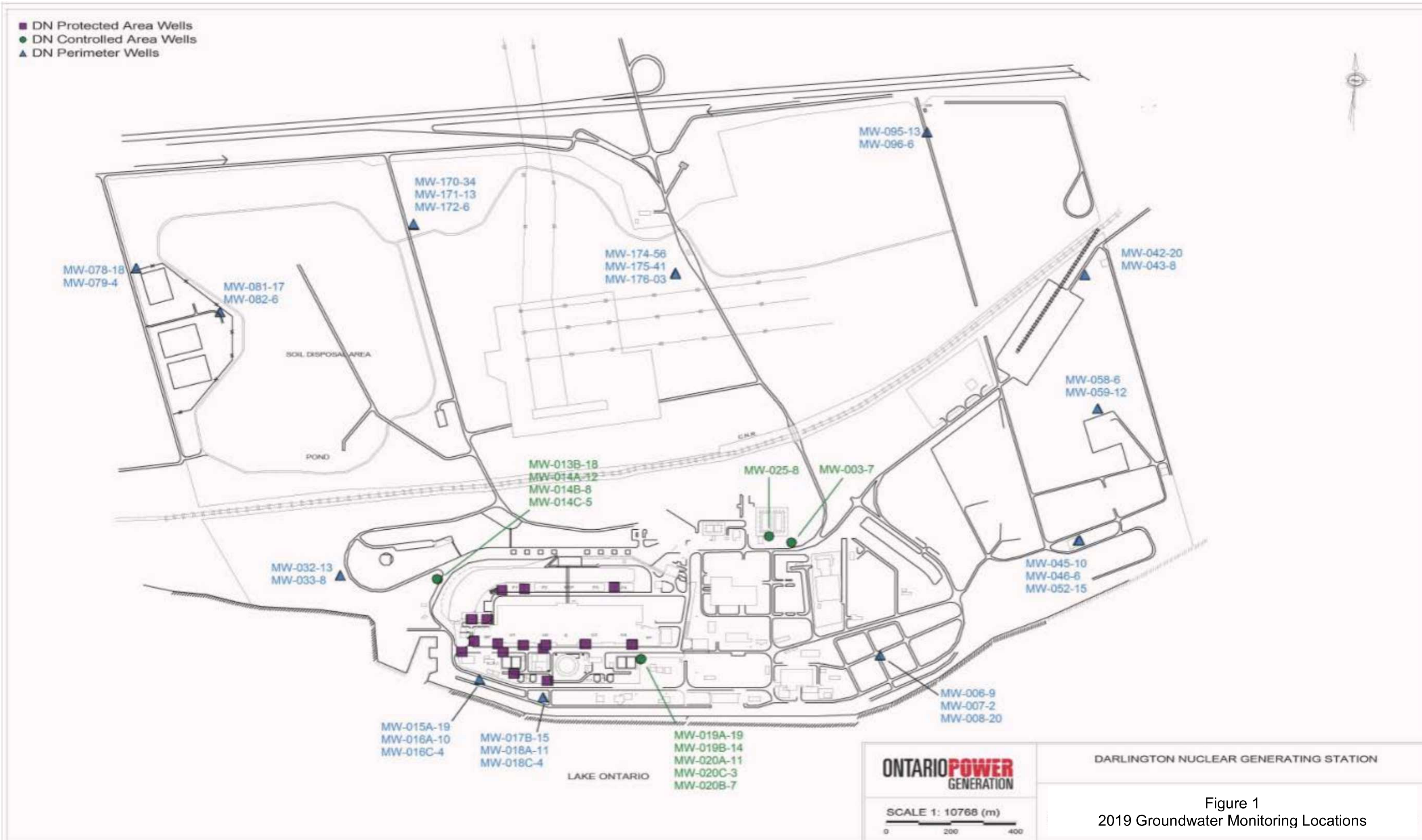


Figure 1: 2019 Groundwater Monitoring Locations

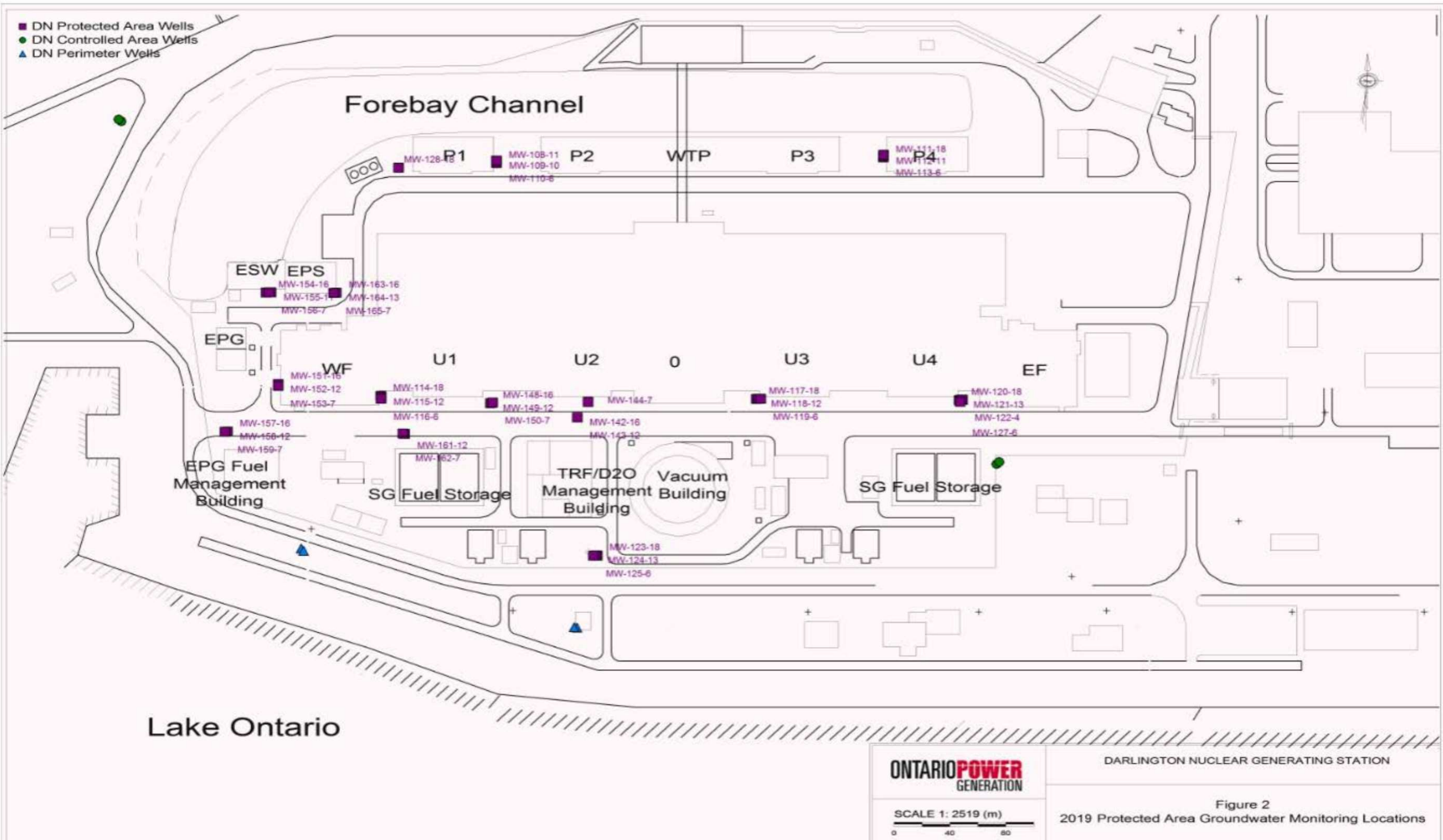


Figure 2: 2019 Protected Area Groundwater Monitoring Locations

3.0 2019 PROGRAM RESULTS

3.1 Objective 1 Results

The predominant groundwater flow patterns remain unchanged in 2019 from the original site groundwater flow interpretations made in 2010.

DNGS's groundwater flow systems are categorized into three hydrostratigraphic units (HU) based on previous hydrogeological investigations:

- Shallow/Water Table;
- Interglacial Deposits; and
- Shallow Bedrock.

Groundwater level measurements collected from the wells installed in each HU were used to confirm the groundwater flow directions. Figure 3 shows the shallow groundwater contours. Groundwater flow directions are interpreted to be perpendicular to the contour lines.

The predominant groundwater flow patterns are summarized as follows:

- In general, groundwater on the site flows from the north and discharges toward Lake Ontario.
- The eastern half of the DNGS site has a component of groundwater flow directed to the east from the north, and then south towards Lake Ontario.
- General flow in the interglacial deposits HU and the shallow bedrock HU are similar to that of water table HU described above. Vertically, groundwater flows predominantly downward from the water table (shallow groundwater) to interglacial deposits or to shallow bedrock.
- Groundwater flow direction is complex inside the protected area due to anthropogenic subsurface features as detailed below:
  - The powerhouse extends to bedrock and acts as a barrier to groundwater flow; therefore, groundwater flow at the water table on the north side of the powerhouse may not be connected or poorly connected to groundwater flow at the water table on the south side of the powerhouse.
  - Groundwater on the north side of the powerhouse discharges into the Forebay Channel as the Condenser Cooling Water pumps lower the Forebay Channel water level, creating a hydraulic gradient directed to the Forebay Channel.

- On the south side of the powerhouse, groundwater flows from the east to the Forebay Channel; however, a component of that groundwater flow is directed to the lake.

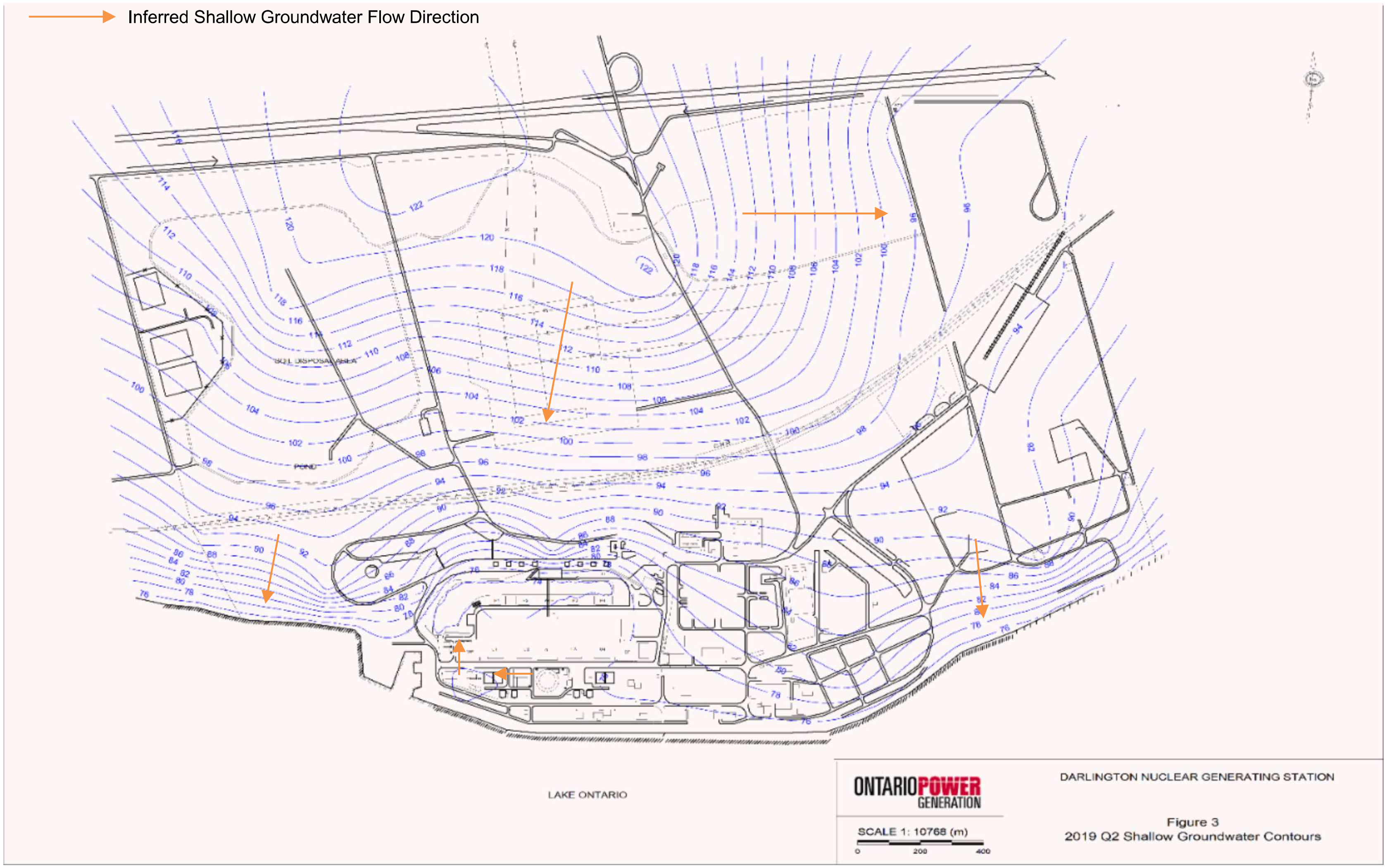


Figure 3: 2019 Q2 Shallow Groundwater Contours

3.2 Objective 2 Results

In 2019, the groundwater data collected from the key areas at DNGS indicate that tritium concentrations have remained constant or decreased over time, which points to stable or improved environmental performance.

3.2.1 Protected Area Groundwater Quality

In 2019, 38 monitoring wells were sampled in the protected area to assess tritium concentrations and trends.

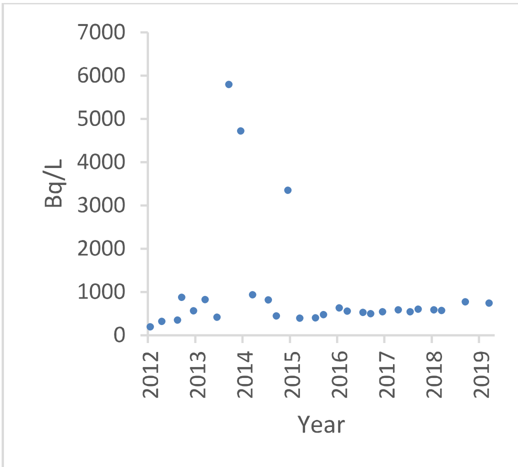
The presence of elevated tritium in groundwater in the protected area is attributed to the Injection Water Storage Tank (IWST) spill, which occurred southwest of Unit 0, in December 2009. Overall, tritium concentrations have declined since the spill, confirming that there are no new sources of tritium in groundwater. At certain locations, slight increases in tritium concentrations were observed in 2019. This includes MW-120-18 and MW-121-13 in the area of Unit 4, with tritium concentrations ranging from 4.30×10^2 Bq/L (0.012 µCi/L) to 9.90×10^2 Bq/L (0.027 µCi/L) in 2019. Groundwater monitoring wells within the protected area will continue to be monitored to verify the tritium concentration trends.

The results are further discussed below, and presented on Figure 4 and Table A-1 (Appendix A). For Figure 4, to simplify the presentation of data, and maintain a conservative approach, the annual maximum tritium concentration at each monitoring well cluster/nest is presented.

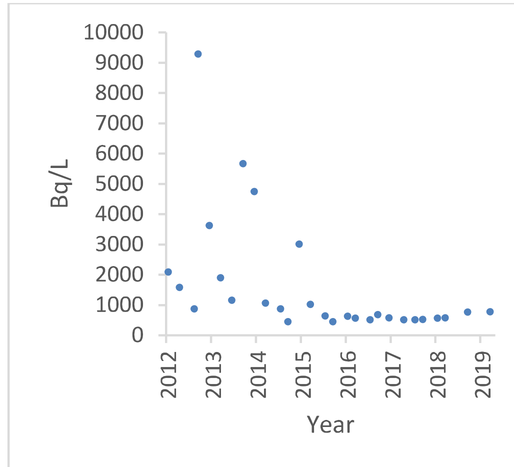
For the ease of discussion, the protected area groundwater results are sub-divided into five smaller areas: Unit 2 (U2) area, West Fueling Facility Auxiliary (WFFA) area, Emergency Power Generator (EPG) Fuel Management Building area, Emergency Power Service (EPS) Building area and the northern side of the powerhouse. These areas are also shown on Figure 4.

<u>U2 Area</u>

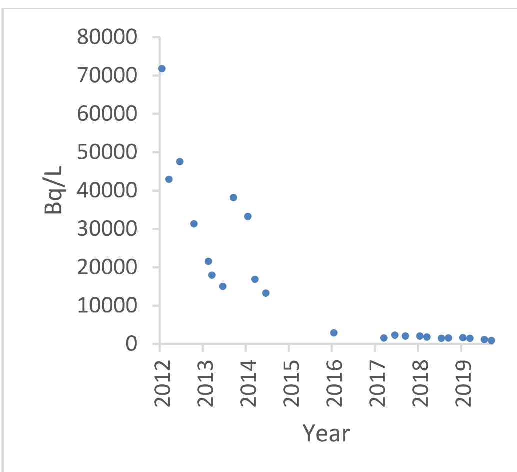
Tritium concentrations at the core of the IWST spill plume, found in the area southwest of Unit 0 and in the vicinity of U2, are declining. In 2019, the highest tritium concentration seen at the monitoring well nest consisting of MW-142-16, MW-143-12 and MW-144-7 was 1.7×10^3 Bq/L (0.046 µCi/L). As in past years, at discrete monitoring locations, tritium concentrations may fluctuate during the year as the tritium in groundwater migrates. Overall, the tritium concentration in this area is expected to continue to show a declining trend. Monitoring will continue. Graphs 1 to 3 depict the data for these monitoring wells.



Graph 1: MW-142-16 Tritium Data



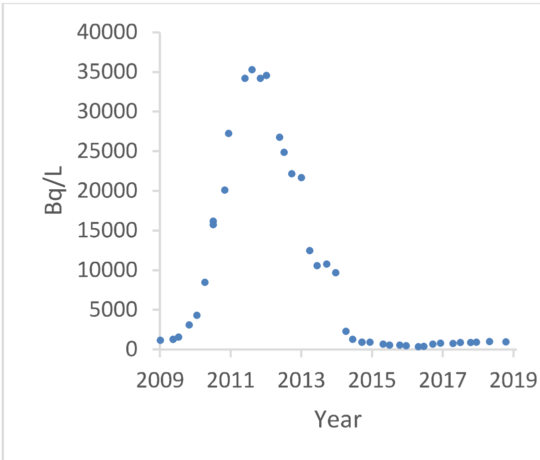
Graph 2: MW-143-12 Tritium Data



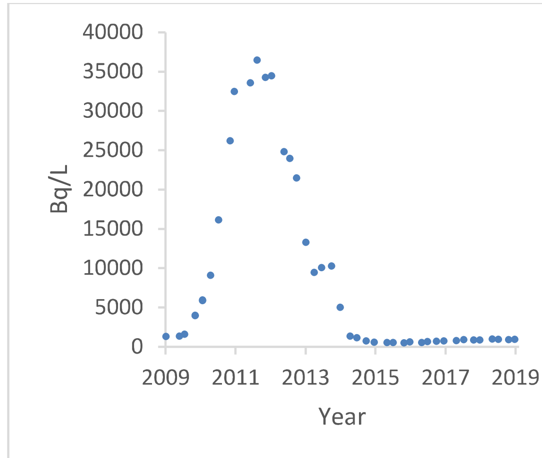
Graph 3: MW-144-7 Tritium Data

WFFA Area

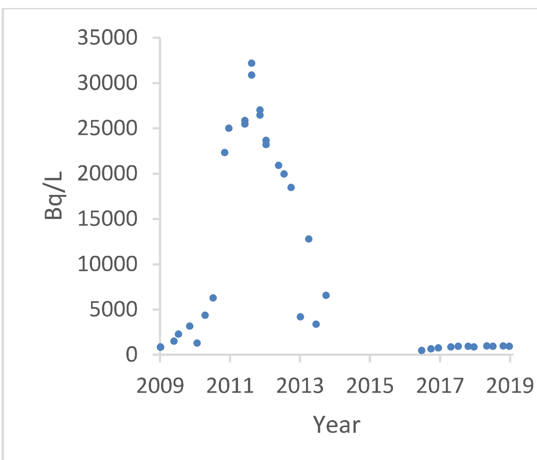
The tritiated groundwater from the IWST spill area has flowed along the southern wall of the powerhouse to the west. The monitoring well cluster consisting of MW-114A-18, MW-115-12 and MW-116-6, located in the vicinity of the WFFA, had tritium concentrations ranging from 9.40 x 10^2 Bq/L (0.025 µCi/L) to 1.02 x 10^3 Bq/L (0.028 µCi/L) in 2019. Tritium concentrations peaked in 2012 and the concentrations have been generally decreasing since then (Graphs 4 to 6). This decline in tritium concentrations is expected to continue. Similar trends are observed in monitoring well cluster further west, consisting of MW-151-16, MW-152-12 and MW-153-7, with tritium concentrations ranging from 6.10 x 10^2 Bq/L (0.016 µCi/L) to 1.11 x 10^3 Bq/L (0.03 µCi/L) in 2019.



Graph 4: MW-114A-18 Tritium Data



Graph 5: MW-115-12 Tritium Data



Graph 6: MW-116-6 Tritium Data

<u>EPG Fuel Management Building Area</u>

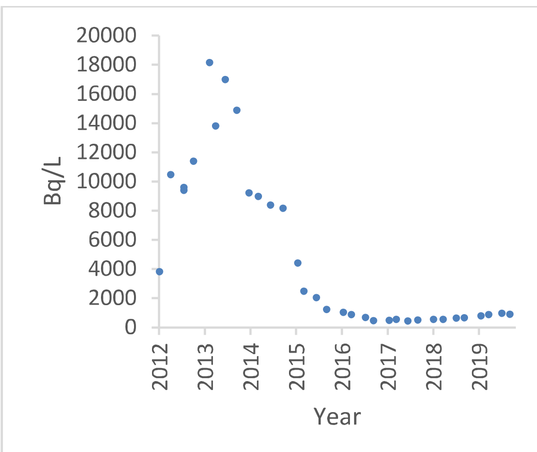
A small component of the tritium in groundwater has migrated west towards the EPG area.

At MW-157-16, an overall downward trend is apparent (Graph 7). In 2019, concentrations ranged from 8.00 x 10^2 Bq/L (0.022 µCi/L) to 9.70 x 10^2 Bq/L (0.026 µCi/L).

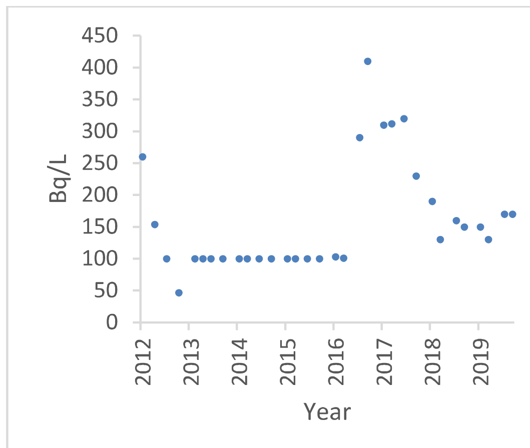
The adjacent deep overburden monitoring well (MW-158-12) has historically shown tritium concentrations at less than the method detection limit of 100 Bq/L (0.0027 µCi/L). In 2016, there was a slight increase in tritium concentrations at this well. In 2019, the concentrations were still above the method detection limit, but have decreased as compared to 2016, with the 2019 results ranging from 1.30 x 10^2 Bq/L (0.0035 µCi/L) to 1.70 x 10^2 Bq/L (0.0046 µCi/L). The results are seen in Graph 8.

The adjacent shallow overburden monitoring well (MW-159-7) is exhibiting a slow upward trend in tritium concentrations with fluctuations (Graph 9). In 2019, concentrations ranged from 8.90 x 10^2 Bq/L (0.024 µCi/L) to 1.36 x 10^3 Bq/L (0.037 µCi/L). The gradual upward trend is likely a rebounding effect following the recovery of groundwater elevations in the protected area (following the cessation of dewatering activities for refurbishment).

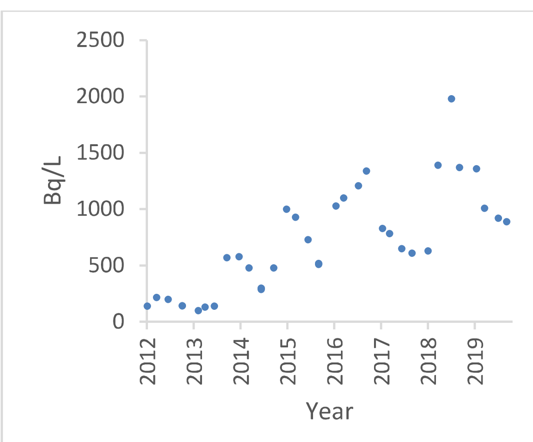
Surveillance will continue in order to track the movement of the tritium plume in the EPG area.



Graph 7: MW-157-16 Tritium Data



Graph 8: MW-158-12 Tritium Data

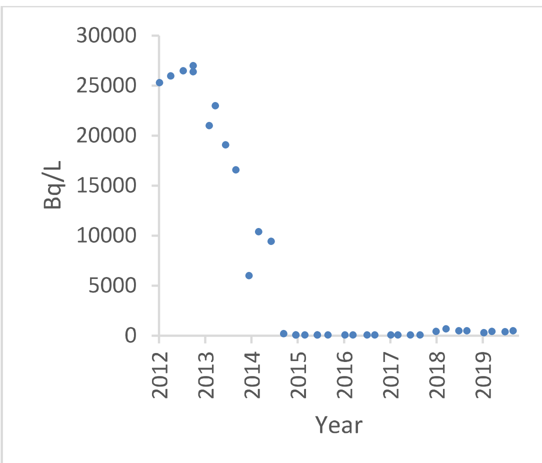


Graph 9: MW-159-7 Tritium Data

EPS Building Area

The majority of the tritium in groundwater from the WFFA area has historically flowed downgradient towards the EPS building area and discharged into the Forebay Channel. Results from MW-154-16, which is located closest to the Forebay, showed a slight increase in tritium concentrations since 2018, with 2019 results ranging from 3.30×10^2 Bq/L (0.0089 µCi/L) to 5.00×10^2 Bq/L (0.014 µCi/L), likely due to migration of tritium toward the Forebay. Overall, a declining trend is still apparent, as compared to concentrations seen historically (Graph 10).

The slow discharge of groundwater into the Forebay Channel is diluted by the large inflow of lake water and this Forebay water is monitored before it is discharged back to the lake.



Graph 10: MW-154-16 Tritium Data

Northern Side of Powerhouse

On the northern side of the Powerhouse, tritium concentrations remained low, ranging from less than 100 Bq/L (0.0027 µCi/L) to 2.20×10^2 Bq/L (0.0059 µCi/L). These concentrations are within the expected tritium concentrations that may result from the infiltration of precipitation. A previous precipitation study indicated that the tritium in precipitation ranged from not detectable to a maximum of 1.92×10^3 Bq/L (0.052 µCi/L), with a maximum average of 5.14×10^2 Bq/L (0.014 µCi/L).

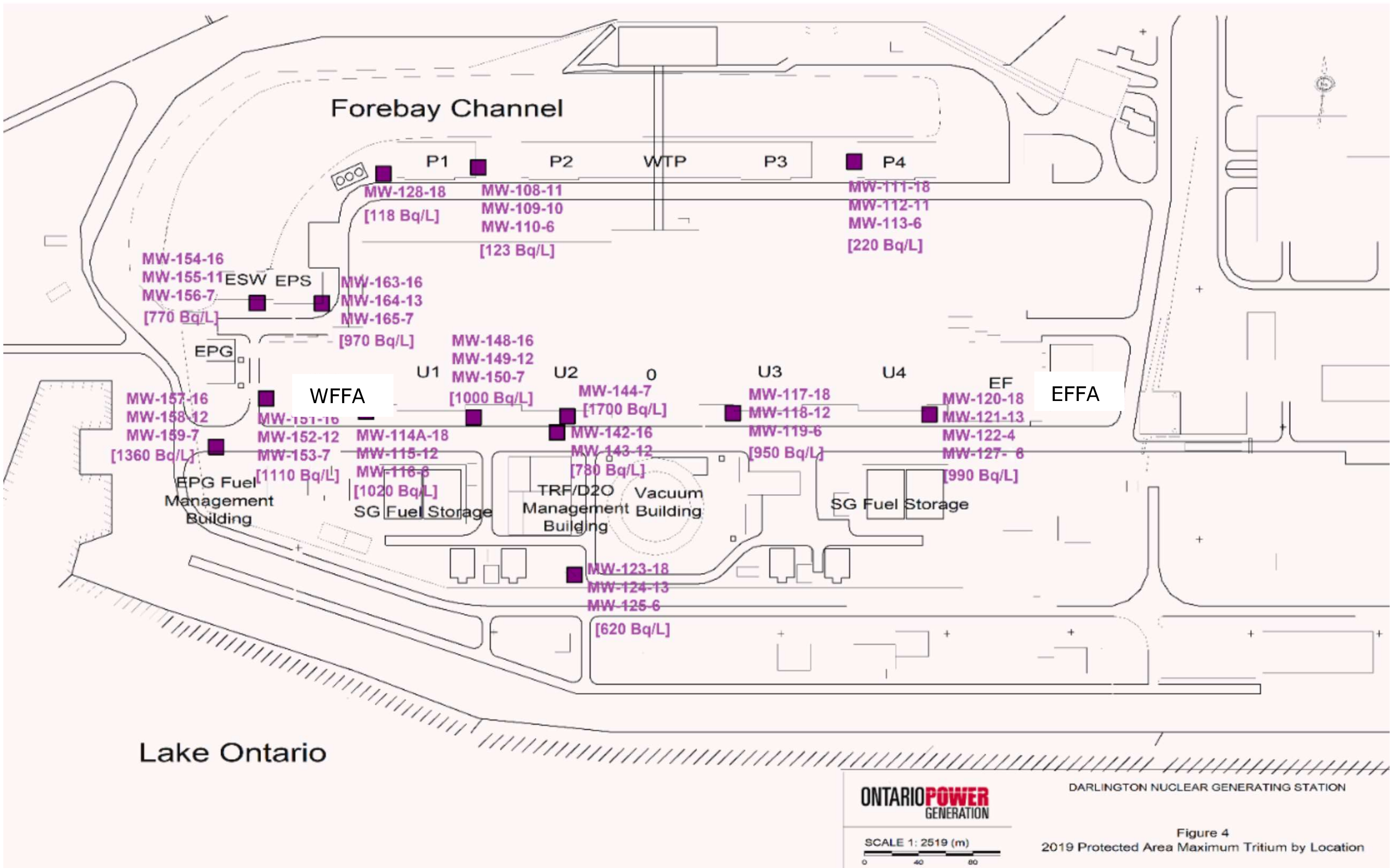


Figure 4: 2019 Protected Area Annual Maximum Tritium by Location

3.2.2 Controlled Area Groundwater Quality

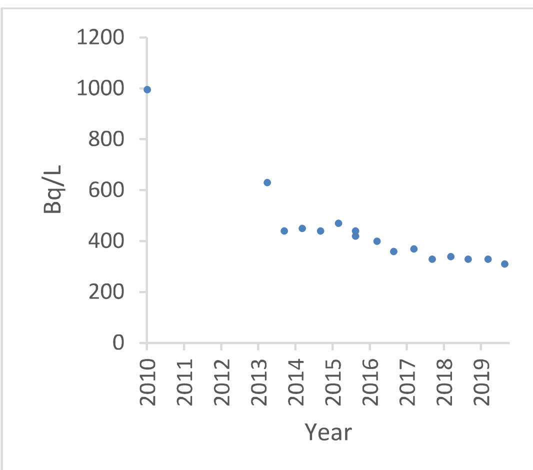
In 2019, 11 monitoring wells were sampled in the controlled area to assess tritium concentrations and trends.

Tritium concentrations in the controlled area wells remained low, ranging from less than the method detection limit of 100 Bq/L (0.0027 μCi/L) to a maximum of 3.60 x 10^2 Bq/L (0.010 μCi/L) at both MW-025-8 and MW-020B-7. Similar concentrations were also observed at MW-003-7.

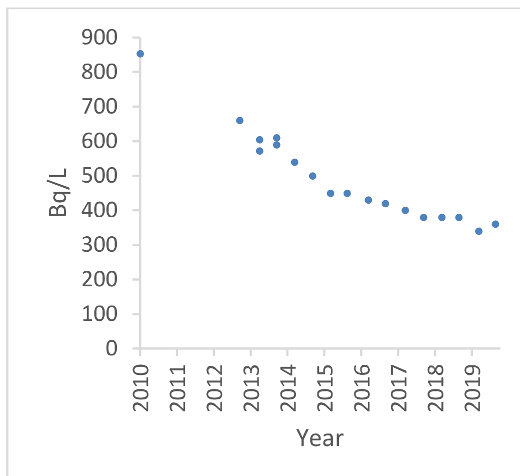
The presence of tritium at MW-003-7 and MW-025-8 is mainly attributed to a past spill from the building effluent lagoon in 2001. Corrective actions to address this spill were implemented. Groundwater monitoring results indicate that tritium concentrations have been declining (Graphs 11 and 12).

Monitoring of groundwater in the controlled area will continue. In particular, surveillance of the lagoon area will continue to ensure due diligence is applied.

The results are further presented on Figure 5 and Table A-2 (Appendix A). Again, for Figure 5, the annual maximum tritium concentration is presented for each monitoring well cluster.



Graph 11: MW-003-7 Tritium Data



Graph 12: MW-025-8 Tritium Data

3.2.3 Petroleum Hydrocarbons and BTEX in Groundwater

In 2019, groundwater monitoring was conducted in the vicinity or downgradient of the Emergency Power Generators, Standby Generators and the Construction Boilerhouse to detect underground fuel oil piping leaks.

Nine monitoring wells were sampled for PHCs and BTEX and their analytical results were compared to the Ministry of the Environment, Conservation and Parks (MECP)

Table 3 Standard: "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act" for 2011, Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition. This comparison was conducted for assessment purposes only, because the Standards are used as a best management practice in this case.

In 2019, there were no results that exceeded the MECP Table 3 standards for PHCs and BTEX. The majority of results were non-detectable.

At MW-143-12, some parameters were detected at concentrations well below the Standards. This monitoring well had shown some exceedances for PHC parameters in past years (2015 and 2016). This monitoring well was repaired in 2015 due to well integrity issues identified at that time (MW-143-12 did not appear to have an adequate seal at surface and may have been experiencing some surface water infiltration). The results indicate that concentrations have declined following the repairs.

The analytical results for PHCs and BTEX are presented in Table A-4 (Appendix A).

3.3 Objective 3 Results

In 2019, 30 monitoring wells located at the property boundary were sampled. Overall, low tritium concentrations at site-perimeter locations indicate that there are no adverse off-site impacts from DNGS groundwater.

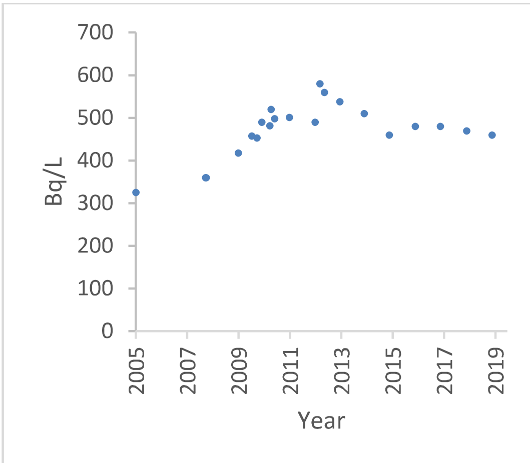
With the exception of MW-016C-4 and MW-033-8, all samples from perimeter monitoring wells had tritium concentrations of less than 100 Bq/L (0.0027 μCi/L).

MW-016C-4, located at the southern perimeter of the station, had a 2019 tritium concentration of 4.60×10^2 Bq/L (0.012 μCi/L). An increasing tritium trend was observed at this well beginning in 2009 (Graph 13). The increase was attributed to a small portion of tritium migrating from the IWST spill area that occurred in December 2009. Concentrations have begun to decrease in the last few years and this decrease is expected to continue over time as the source term diminishes.

MW-033-8, located at the western perimeter of the station, exhibited a tritium concentration slightly above the method detection limit of 100 Bq/L (0.0027 μCi/L). The 2019 concentration was 1.31×10^2 Bq/L (0.004 μCi/L) in 2019. This monitoring well will continue to be monitored.

As part of the annual OPG DNGS Environmental Monitoring Program, municipal drinking water samples are collected from the downstream Water Supply Plants (WSPs). In 2019, the data from this sampling demonstrated that the annual average tritium concentration at each WSP was well below the Ontario Drinking Water Quality Standard (ODWQS) for tritium of 7,000 Bq/L. This further supports that there were no indications of adverse off-site impacts from DNGS groundwater.

The data for all of the perimeter groundwater monitoring locations are presented on Figure 5 and Table A-3 (Appendix A).



Graph 13: MW-016C-4 Tritium Data

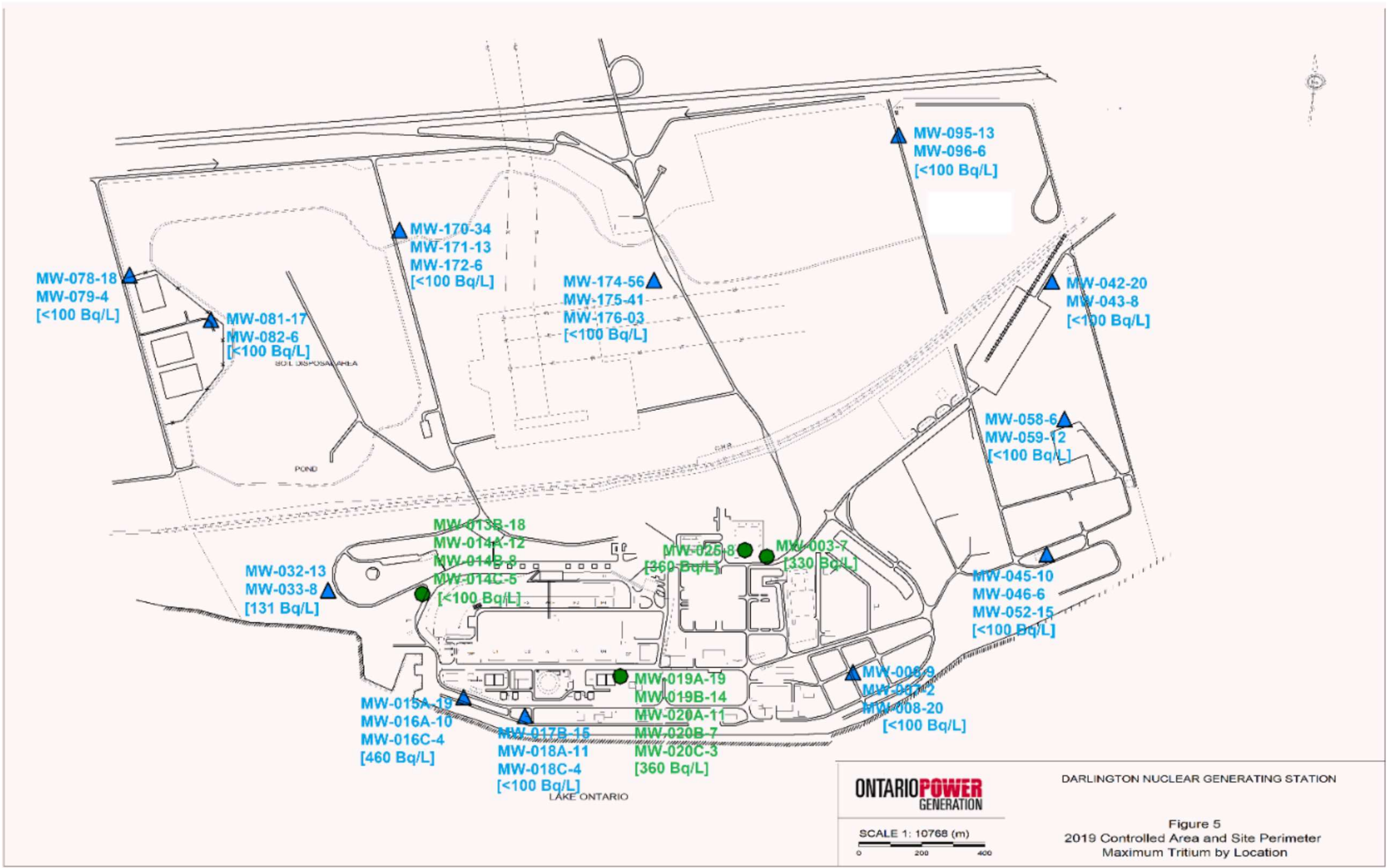


Figure 5: 2019 Controlled Area and Site Perimeter Maximum Tritium by Location

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance and Quality Control for the groundwater monitoring program encompasses all activities in field sample collection, laboratory analysis and laboratory quality control. The objective is to provide confidence in the interpretation of the DNGS groundwater monitoring data through a systematic and documented process.

4.1 Quality Assurance Program for Laboratories

Bureau Veritas is accredited to ISO 17025 by the Standards Council of Canada for environmental tests. Many of the conventional parameters are governed by criteria established in MECP's "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act". Bureau Veritas has a Quality Assurance Department, which routinely monitors procedures and processes by way of compliance audits, quality system audits and method audits to ensure compliance with accreditation and regulatory requirements. Bureau Veritas is also accredited by the Standards Council of Canada for radiological tests.

4.2 Quality Control Results

Duplicates, field blanks, and travel blanks were collected at a prescribed frequency to measure sampling and analytical performance.

In 2019, field duplicate samples were collected from 11 monitoring locations. The analytical results and calculated relative percentage differences (RPD) were evaluated to understand the sampling precision. The RPD values were less than 20 percent in all instances, ranging from zero to 8 percent. It can be concluded that the field technique and the laboratory's analytical methods were reproducible and reliable.

All field blank results were non-detectable. Therefore, no significant contamination of those samples occurred during the sample collection process.

Similarly, all travel blank results were non-detectable as well, indicating that there was no contamination of the samples during handling and transportation.

The sample results discussed above are presented in Tables A-5 and A-6 (Appendix A).

5.0 SUPPLEMENTARY STUDIES AND AUDITS

There were no supplementary studies related to DNGS groundwater initiated in 2019. There were no audits completed on the DNGS groundwater program in 2019.

6.0 CSA N288.7 UPDATE

OPG has committed to the Canadian Nuclear Safety Commission (CNSC) to be compliant with Canadian Standards Association (CSA) N288.7, "Groundwater

Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills", for the Darlington site by December 31, 2022. A gap analysis was completed in 2017. In 2018, OPG retained a vendor to assist with the implementation of the standard at all of the nuclear facilities, and this work continued into 2019. OPG will provide another update in the 2020 report.

7.0 ACRONYMS

μCi/L	*Micro-curie per Litre*
Bq/L	*Becquerel per Litre*
BTEX	*Benzene / Toluene / Ethylbenzene / Xylenes*
CSA	*Canadian Standards Association*
CNSC	*Canadian Nuclear Safety Commission*
DNGS	*Darlington Nuclear Generating Station*
EMP	*Environmental Monitoring Program*
EPG	*Emergency Power Generator*
EPS	*Emergency Power Service*
HU	*Hydrostratigraphic Unit*
IWST	*Injection Water Storage Tank*
MECP	*Ministry of the Environment, Conservation and Parks*
MW	*Monitoring Well*
ODWQS	*Ontario Drinking Water Quality Standard*
OPG	*Ontario Power Generation*
PHC	*Petroleum Hydrocarbon*
RPD	*Relative Percentage Difference*
SAP	*Sampling and Analysis Plan*
WFFA	*West Fueling Facility Auxiliary*
WSP	*Water Supply Plant*

Appendix A: Tables A-1 to A-6